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German to English Translation

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DECLARATION

The undersigned, Amy L. Menge, hereby states that she is well acquainted with both the English and German languages and that the attached is a true translation to the best of her knowledge and ability of the German text of PCT/EP2005/051155, filed on March 15, 2005 and published on October 6, 2005.

The undersigned further declares that the above statement is true; and further that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

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Description

Optical Systems for Producing an Illuminated Strip

The invention relates to optical systems for producing an illuminated strip in accordance with the generic portion of Claim 1, 9, or 98.

The application is used primarily in connection with the recording of images of machine-processed material in the field of industrial image processing, for example of imprinted material processed in connection with stocks and bonds, wherein the optical system is used in or on a printing press, preferably in or on a rotary printing press, in particular in or on a printing press operated by means of an offset printing method, a steel engraving method, a screen printing method or a hot-process embossing method. Alternatively or additionally to the arrangement in or on a printing press, the optical system can also be arranged in or on a machine which further processes a printed product. Image recording is performed for the purpose of an at least partial, preferably complete image representation of the moving imprinted material, with or without taking a measurement of previously determined characteristics of this material, in order to evaluate this material regarding the quality of a process step previously performed in the machine. Optical systems of this type are employed, for example, in an inline inspection system and therefore are a component of an inline inspection system.

An image reading device is known from DE 35 27 300 C2, wherein an illumination arrangement with several groups of light sources is provided, wherein the groups of light sources emit light for generating an illuminated strip, wherein a control arrangement operates the groups of light sources in a pulsed manner, wherein photo-sensors arranged in rows detect light reflected from the surface of the material, wherein the photo- sensors constitute a line-scanning camera, wherein an electrical current source controlled by the control arrangement is assigned to the groups of light sources, wherein a length of time in which the light sources are switched-on is synchronized with a length of the line-scanning camera exposure time.

A method for checking web-shaped transparent material, in particular a paper web, suitable for application in the print industry, is known from DE 41 02 122 A1, wherein flashbulbs constructed from light-emitting diodes or laser diodes radiate through a paper web, so that light

being radiated through the paper web impinges on a CCD matrix of a camera for generating a video signal, wherein light leaving the illumination arrangement in the direction of the paper web radiates through a frosted diffusor disk.

A printing press with an inline image inspection system for the inspection of a printed product produced in the printing press is known from DE 43 21 177 A1, wherein an image detection arrangement is provided, which delivers image data of the printed product to a computing device, wherein the image detection arrangement consists of a measuring module, or several measuring modules, each of which scans a defined image area of the printed product, and of at least one associated receiving device, which makes the image data available in an electric form and which is preferably spatially separated from the measuring modules, wherein the measuring modules and the at least one receiving device are connected with each other by at least one image conductor, wherein an illumination arrangement consisting of precision halogen lamps is assigned to the image detection device wherein, when charged with blowing air, a blow pipe with openings in the direction of the printed product maintains the printed product at a defined distance from the illumination arrangement and simultaneously cools the illumination arrangement by means of the blowing air.

An illumination arrangement for an optical inspection system for the inspection of surfaces is known from DE 100 61 070 A1, wherein several support panels, which are preferably of the same length and are electrically connected with each other, each with several rows of light-emitting diodes, have been inserted in a line-shaped manner into a common rigid, profiled mounting device, which can be cut in length to correspond to an object surface which is to be scanned by means of constant light radiation, wherein a thermal connection between the support

panels and the profiled mounting device for cooling the light-emitting diodes and their electronic control device is provided by means of a mechanical connection.

A device for the quality control of printed matter is known from DE 202 13 431 U1, which also constitutes an inline image inspection system arranged in a printing press, wherein an illumination arrangement designed as a fluorescent tube and an image recording device designed as a line-scanning camera are employed.

An inline image inspection system for a printing press, in particular a sheet-fed offset printing press, is known from DE 203 03 574 U1, wherein an illumination arrangement designed as a fluorescent tube is arranged underneath a foot pedal close to a counter-pressure cylinder conveying an imprinted material, and an image recording device designed as a line-scanning camera is arranged at a comparatively greater distance from the counter- pressure cylinder in association with the last printing group of the printing press.

A device for a line-shaped illumination of sheet material, such as banknotes and securities, is known from EP 0 762 174 A2, wherein a cylindrical mirror with two mirror segments is provided, wherein the mirror segments form an elliptical base surface having two focal lines, wherein the width of the mirror segments has been selected to be larger than or equal to the width of the sheet material, wherein the sheet metal, which is transported in the transport direction perpendicularly to the first focal line, is arranged in this first focal line, and a cold light source, for example a row of light-emitting diodes (LEDs), is arranged in the second focal line, wherein a detector, for example a CCD array, or photodiodes arranged individually or in groups, detects the light reflected by the sheet material and converts it into signals for processing in a processing installation.

An inspection system is known from USP 4,972,093, wherein a moving test object is subjected to a strobe of light lasting between 20 ms and 200 ms from a light-emitting diode arrangement which is controlled in a pulse-like manner, and an area-scanning camera takes a picture of the entire test object.

An optical system for creating an illuminated pattern on a surface of a material which is moved relative to the pattern is known from USP 5,936, 353, wherein an illumination arrangement with several light sources switched in series emits light for creating the pattern, wherein a detection device with at least one detector detects light reflected from the surface of the material, wherein the light sources are arranged on a panel, wherein the panel is arranged on a support, wherein the support has at least one conduit in its interior, wherein a liquid or gaseous cooling medium for cooling the light sources flows through the conduit.

A device for the control of light-emitting diodes with a constant current source, which form a line-shaped illumination arrangement, is known from JP 1-255 371 A, wherein a driving circuit of the light-emitting diodes is connected with a line- scanning camera via a scanning control circuit and a multiplexer, so that light-emitting diodes of the illumination arrangement, which are in operative connection with each other, and photo- sensors of the line-scanning camera are synchronized with each other.

The object of the invention is to create optical systems for the production of an illuminated strip in which, in an arrangement that is independent of the focal point, the illuminated strip can be subjected to a homogeneous, high degree of brightness, with the length of the illumination device being easily adaptable at need.

This object is attained according to the invention by the features of Claim 1, 8, or 98.

The advantages that are attainable with the invention lie especially in the fact that the illumination device has an extremely compact structure by virtue of its reflector module with the functions integrated therein and therefore may be integrated without a problem into a printing press or a machine that subsequently processes a printed product. In spite of the compact construction of the illumination device, the illuminated strip is illuminated intensively and without shadows because the reflector module forms the optical path of the light emitted by the light sources, homogenizes the emitted light beams, and bundles them in a targeted manner to form a narrow band of light. The use of a reflector module also allows the formation of an illumination device that can be easily scaled in the longitudinal direction such that the illumination device can be adapted to any required format width of the material.

A further advantage lies in that the material on whose surface the pattern is to be created need not be arranged in a focal point, which is located in a direct or a redirected beam path of the light emitted by the light source in order to make the pattern appear with a sufficiently strong illumination. An arrangement of the pattern relative to the optical system, which is independent of the focal point, is advantageous, because in that case it is possible to do without an exact dimensional accuracy regarding the distance between the pattern and the illumination arrangement. The distance of the proposed optical system is therefore tolerant in regard to the illuminated material. Moreover, a sufficient distance is provided between components of the optical system, whose function could be impaired by soiling, for example by dust or rubbed-off particles, and the material, in particular also in regard to a transport device which moves the material, which, under the existing operating conditions in a printing press, keeps the optical system and the material out of direct contact, and preferably arranges the optical system outside the range of the particles of dirt stirred up by the moving material.

An illuminated strip, which is illuminated by the illumination arrangement and is of a width which orthogonally extends on the surface of the material in respect to its length, i.e. a two-dimensional flat pattern, has the advantage over a line-shaped, i.e. only one-dimensional illuminated pattern, which is focused on a focal point, that the illuminated pattern dependably appears as a virtual line-shaped illumination arrangement to a detection device for detecting the light reflected by the surface of the material, which is arranged under a reflective angle in respect to a surface of the material which is reflective at least in part, even if the surface of the material is designed to be in a relief shape, because it is assured, based on the width of the illuminated strip, that a cross-sectional surface of a detection angle of the detection device which exists on the surface of the material and within which the detection device is capable of detecting reflected light, will detect at least a portion of a cross-sectional surface of the light beam emitted by the illumination arrangement which extends over the width of the illuminated strip. There is the danger in connection with a device which illuminates the material only in a line-like manner that the focused light beams are reflected by a relief-like surface of the material outside of the detection angle of the detection device, so that as a result it cannot be detected. In contrast thereto, the proposed optical system is also well suited for taking pictures of material with a diffusely reflecting surface. A shading effect hardly occurs, even with a material with a relief-like surface.

The illumination arrangement of the proposed optical system is preferably constructed by means of modules, i.e. in independent functional units, which has the advantage that the length of a line of the line-shaped illumination arrangement can be adapted, without an expensive special production, by means of a simple alignment of prefabricated, preferably functionally identical

modules in the required amounts to the width of the material to be illuminated, or at least to the width of the illuminated strip. It is possible in the same way to activate the light sources in a selective positive manner only in those modules which are required for illuminating the width of the material to be illuminated, or at least the length of the illuminated strip, which has advantages regarding the efficiency of the construction and operation of the optical system.

The employment of a plurality of light sources per module has the advantage that differences in the light emitted by the light sources, which are unavoidable in actual use, for example its wavelength, are compensated by mixing the light beams of adjoining light sources, and that the optical properties of the light emitted as a whole by the illumination arrangement are homogenized. If preferably several groups of light sources are arranged in each module, wherein the light sources assigned to the groups differ in their optical properties, for example in the color of the light emitted by the light sources of each group, the individual groups of light sources can be selected in accordance with their application, for example by color, and controlled.

The proposed optical system has the advantage that it charges an illuminated strip which possibly has a considerable length, for example more than a meter, with a homogeneous, sufficiently large illumination strength by means of an even light distribution in accordance with the requirements, and can be adapted in a simple way to the respective requirements in connection with a printing press by means of its modular construction, which is not very susceptible to interference. Since the material to be illuminated need not be arranged in a focal point of the illumination arrangement, the requirement for an exact alignment of the vertical distance of the light sources in respect to the surface of the material, as well as the monitoring of this distance during the running employment of the optical system, can also be omitted, which considerably simplifies the manipulation of the optical system at the site in an industrial

installation.

The advantages to be gained by means of the invention consist in particular in that the surface of the moving material is always illuminated with the same amount of light, regardless of the speed of the moving material, because of which a constant brightness results for image recording, and unusable image recordings are avoided. Also, the length of time that the light source is switched on always constitutes a partial amount of the length of the exposure time of the line-scanning camera, so that a fixed correlation between the length of time that the light source is switched on and the length of the exposure time of the line- scanning camera is always assured for the timing. As a rule, a digital line-scanning camera has an electronic shutter which, at the end of the exposure time of the line-scanning camera, puts out a read-out pulse for reading out the electrical charge collected by the detectors as a result of the light reflected from the surface of the moving material. So-called overflowing of the detectors of the line-scanning cameras which are sensitive to electrical charges is avoided by means of the correlation in accordance with the invention between the time the light source is switched on and the exposure time of the line-scanning camera. Instead, in an advantageous manner a barrier results over a wide range of the speed of the moving material and therefore an unequivocal separation between detectors which are successively arranged in the movement direction of the line-scanning camera.

Exemplary embodiments of the invention are represented in the drawings and will be explained in greater detail in what follows.

Shown are in:

Fig. 1, a surface of a moving material with an illuminated strip in a view from above,

Fig. 2, a schematic representation of the optical system,

Fig. 3, an individual light source of the illumination arrangement,

Fig. 4, a line-like arrangement of light sources on a common board,

Fig. 5, a light beam concentration by means of a first mirror,

Fig. 6, a light beam concentration by means of a first mirror along the length of the illuminated strip,

Fig. 7, a redirection of the light beam out of a central area of the light source by means of a second mirror,

Fig. 8, a redirection of the light beam out of a central area of the light source by means of a second mirror, wherein the beam is more tightly focused along the length of the illuminated strip than along its width,

Fig. 9, focusing of the beam from a central area of the light source by means of a convex lens,

Fig. 10, focusing of the beam from a central area of the light source by means of a convex lens, wherein the beam is more tightly focused along the length of the illuminated strip than along its width,

Fig. 11, an at least partial superimposition of the beams from two adjoining light sources with a scattering body placed in front,

Fig. 12, a lateral view of the optical system,

Fig. 13, a board equipped with light sources on a support through which a cooling medium flows,

Fig. 14, a support through which cooling medium flows in two opposite directions,

Fig. 15, a support with a cooling device with two Peltier elements,

Fig. 16, a representation of the chronological behavior of the line-scanning camera and of that of the light sources,

Fig. 17, a reflector module in a perspective plan view.

A material 03 with a surface 02, represented in Fig. 1, is moved in a movement direction 04 indicated by an arrow in a printing press, in particular in a printing press operating by means of an offset printing process. The movement takes place by means of a transport device, not represented here, arranged in or on the printing press, wherein the movement of the material 03 in the course of the operation of the optical system, which will be described in greater detail in what follows, preferably occurs in only one movement direction 04, and this preferably linearly. The speed of the moving material can be constant, or also variable.

Preferably the material 03 is embodied with a level surface and flat, for example as a sheet 03 or a web 03 of material. In particular, the material 03 is embodied as an imprinted material 03, for example consisting of paper and, for example, in the form of securities 03 or as a banknote 03. The surface 02 of the material 03 can have a relief shape or other structure protruding from the surface 02, or a structure embossed into the surface 02 in the form of a depression, wherein the height or depth of the relief or the structure is very little in comparison with a width B03 of the material 03. At least a portion of the surface 02 of the material 03 is embodied to be reflecting, for example by the application of a reflective material, for example a lacquer, or a foil, by the introduction of a window thread or other, preferably metallic substance into the material 03.

An illumination arrangement 06, only symbolically represented in Fig. 2, creates an illuminated pattern 01, preferably in the form of an illuminated strip 01 of a length L01 and a width B01 (Fig. 1), wherein the width B01 extends on the surface 02 of the material 03

orthogonally in relation to the length L01. Preferably the width B01 of the illuminated strip 01 is oriented in the movement direction 04 of the material 03, while the length L01 of the illuminated strip 01 is preferably oriented parallel with the width B03 of the material 03 and can extend over portions of the width B03 of the material 03 or over its entire width B03. For example, the width B01 of the illuminated strip 01 is at least 3 mm, preferably at least 8 mm. Therefore the movement direction 04 of the material 03 is directed at least substantially parallel in respect to the width B01 of the illuminated strip 01, wherein the movement direction 04 of the material 03 lies within the plane defined by the length L01 and the width B01 of the illuminating strip 01. Preferably the material 03 does not bulge, at least in the area of the illuminated strip 01.

The illumination arrangement 06 has a plurality of light sources 07 arranged side-by-side in a line-shaped manner, so that the entire illumination arrangement 06 is embodied to be line-shaped. The light sources 07 of the illumination arrangement 06 arranged in a line-shaped manner are preferably arranged parallel in respect to the length L01 of the illuminated strip 01. The light sources 07 have a respective distance A07 from the surface 02 of the material 03, wherein the distance A07 preferably lies between 30 mm and 200 mm, in particular between 70 mm and 140 mm. Preferably the distance A07 respectively extends perpendicularly in respect to the surface 02 of the material 03. All light sources 07 of the illumination arrangement 06 are preferably identically designed, for example as bright, high-intensity light- emitting diodes 07, or as laser diodes 07. It is also possible to provide groups of several light sources 07, respectively arranged in a line-shape side-by-side, in the illumination arrangement 06, wherein the individual groups of light sources 07 differ in their optical properties, for example the wavelength, of the light emitted by them. For example, one group of light sources 07 can emit white light, while another group of light sources 07 emits monochrome light. It can be provided that a control

device 23 connected with the illumination arrangement 06 selects the groups of light sources 07 in accordance with color of the light as a function of their application, for example as a function of the nature of the surface 02 of the material 03, and controls them individually. In this way the control device 23 can also control a group of light sources 07 independently of at least one other group of light sources 07 in regard to their brightness and/or length of illumination. The illuminated strip 01 is arranged outside of the focal point located in the direct or redirected beam path of the light emitted by the light sources 07.

The illumination arrangement 06 consists for example of several modules M61 to M65 (Fig. 12), which are aligned side-by- side in a line, each having several light sources 07 arranged in a line next to each other, wherein a partition 26 between two adjoining modules M61 to M65 is preferably arranged obliquely in relation to the length L01 of the illuminated strip 01. The individual modules M61 to M65 of the illumination arrangement 06 can be designed to perform identical functions, for example. In this way it is possible, for example, to activate a line length of the illumination arrangement 06 composed of several side-by-side arranged modules M61 to M65, which corresponds to the width B03 of the material 03 to be illuminated, by switching on the light sources 07, which are arranged in a line, of the modules M61 to M65 involved, or it is possible to activate a line length corresponding to the length L01 of the illuminated strip 01 composed of several side-by-side arranged modules M61 to M65 by switching on the light sources 07, which are arranged in a line, of the modules M61 to M65 involved. It is also possible to activate the light sources 07 of individually selected modules M61 to M65 independently of the light sources 07 of other M61 to M65.

In an only two-dimensional representation, Fig. 3 shows an individual light source 07 of the illumination arrangement 06. The light source 07 emits its light at a solid angle omega, wherein

the solid angle omega covers an area AK cut out of a sphere, i.e. a surface AK of the sphere, up to the size of a hemisphere.

Fig. 4 shows several, for example four, of the light sources 07 represented in Fig. 3, which are arranged next to each other in a line on a common board 21. The electrical current source 22 assigned to the respective light sources 07 is preferably also arranged on the same board 21. The electrical current source 22 is preferably designed as a constant electrical current source 22, in particular as a controllable constant electrical current source 22.

A part of an optical system, which preferably is a component of an inspection system arranged on or in a printing press or a machine which further processes a printed product, and which is used for assessing the quality of a printed product produced by means of the printing press, besides the illumination arrangement 06 such as can be taken from Fig. 2, also is at least one detection device 08 with at least one detector 09, which is arranged at a distance A09 from the surface of the material 03, wherein the detector 09 detects light reflected by the surface 02 of the material 03. The detection device 08 is designed, for example, as a camera 08, preferably a line-scanning camera 08, in particular a line-scanning color camera 08. The detection device 08 also preferably has a plurality of detectors 09 arranged side- by-side in a line next to each other, wherein the detectors 09 arranged in a line preferably are arranged parallel in respect to the length L01 of the illuminated strip 01 and/or parallel in respect to the width B03 of the material 03. A distance between lines of detectors 09 arranged in lines preferably extends in the same direction as the movement direction 04 of the material 03, i.e. lines of the detector 09 arranged following each other in the movement direction 04 of the material 03 are preferably arranged orthogonally in respect to the movement direction 04 of the material 03. The detector 09 of the detection device 08 can for example be embodied as a CCD array 09 or as a group of photodiodes 09. The detector 09 of the detection device 08 converts the detected reflected light into an electrical signal and

supplies the electrical signal for being evaluated to an image processing device 24, which is connected with the detection device 08.

Fig. 5 shows that in the optical system at least one first mirror 11 with an effective surface 12 oriented along the length L01 and/or the width B01 of the illuminated strip 01 is assigned to the light sources 07, wherein the effective surface 12 of the first mirror 11 restricts the light emitted in the solid angle omega by at least one of the light sources 07 of the illuminating arrangement 06 to a smaller first envelope surface AH1 than the spherical surface AK which is part of the solid angle omega. The effective surface 12 of the first mirror 11 can be embodied to be flat or concave. In this case the at least one effective surface 12 of the first mirror 11 oriented along the length L01 of the illuminated strip 01 can restrict the light from at least one of the light sources 07 of the illumination arrangement 06 directed into the solid angle omega more closely to a second smaller envelope surface AH2 than the at least one effective surface 12 of this first mirror 11 which is oriented along the width B01 of the illuminated strip 01, such as is shown in Fig. 6 in comparison with the beams in accordance with Fig. 5. Preferably at least one light source 07 of the illumination arrangement 06 has a first mirror 11 with at least two effective surfaces 12, which are symmetrical in respect to the central beam 13 emitted by the light source 07.

For redirecting the radiation emitted by at least one of the light sources 07 of the illumination arrangement 06 in a central area 14 surrounding the central beam 13, a second mirror 16 can be provided, as represented in Figs. 7 and 8, wherein its at least one effective surface 17 is arranged in the central area 14 surrounding the beam path of the central beam 13 within the solid angle omega of the light emitted by the light source 07, wherein the effective surface 17 of the second mirror 16 redirects the light emitted by at least one of the light sources 07 of the illumination arrangement 06 against at least one effective surface 12, which is directed along the length L01 and/or width B01

of the illuminated strip 01, of the first mirror 11. In this case the light emitted by the light source 07 can preferably be more tightly focused along the length L01 of the illuminated strip 01 than along its width B01. The effective surface 17 of the second mirror 16 can also be embodied to be flat or concave. The light beams to be assigned to the central area 14 and emitted by the respective light sources 07 are respectively indicated in Figs. 7 to 10 by solid arrow lines, while the light beams which are peripherally emitted in their respective solid angles omega by the light sources 07 are indicated by dashed arrow lines.

In accordance with Figs. 9 and 10 it is alternatively also possible for the redirection of the light beams emitted by at least one of the light sources 07 of the illumination arrangement 06 in a central area 14 surrounding the central beam 13 to arrange at least one lens 18, in particular a biconcave lens 18, in the central area 14 surrounding the central beam 13 within the solid angle omega of the light emitted by at least one of the light sources 07 of the illumination arrangement 06, wherein a distance A18 exists between the light source 07 and a center Z18 of the lens 18, wherein the distance A18 is advantageously less than half the distance A07 between the light source 07 and the surface 02 of the material 03. In this case the lens 18 can be embodied to be not rotationally symmetrical, in order to preferably focus the light emitted by the light source 07 more tightly along the length L01 of the illuminated strip 01 than along its width B01.

Fig. 11 shows that the light sources 07 of the illumination arrangement 06 are preferably arranged in such a way that the respective solid angles omega, or at least the envelope surfaces AH1, AH2 of the light emitted by at least two adjoining light sources 07 of the illumination arrangement 06, are overlaid on each other in at least a partial area 19 which illuminates the illuminated strip 01. This overlay is in particular also provided if the concerned adjoining light sources 07 are arranged in two adjoining modules M61 to M65. It can also be seen in Fig. 11 that

a respective first mirror 11 with at least one effective surface 12, preferably with two effective surfaces 12 which are symmetrical in respect to each other, can be provided at each individual light source 07 of the illumination arrangement 06, at least along the width B01 of the illuminated strip 01.

Furthermore, the illumination arrangement 06 can have a scattering body 38, i.e. a light-scattering body, for example a lenticula or a prism foil, at a side facing the surface 02 of the material 03, i.e. at a light outlet side of the arrangement 06, wherein the scattering body 38 distributes the light radiated by the light sources 07 onto the surface 02 of the material 03 preferably exclusively, or at least quite preponderantly, along the length L01 of the illuminated strip 01. In a preferred embodiment the scattering body 38 and at least one of the mirrors 11, 16 of the illumination arrangement 06 are embodied as a single component, called a reflector module 39, wherein preferably a group of, for example five or ten, light sources 07 arranged in a line next to each other respectively radiate their light into a reflector module 38 arranged along this row of light sources 07. For this purpose the light sources 07 are arranged on the side of the reflector module 38 located diametrically opposite the light outlet side or even recessed there in the reflector module 39. The reflector module 39 is a component which has been produced, for example, from a preferably transparent material by means of injection-molding techniques. Therefore the reflector module 39 is designed as a particularly massive molded part, in which the scattering body 38 and at least one of the mirrors 11, 16 are together formed in such a way that no optically relevant border surface separates the scattering body 38 from the at least one mirror 11, 16. Fig. 17 shows in a perspective plan view and by way of example a reflector module 39 with a scattering body 39, preferably embodied integrated, at the light outlet side, wherein the scattering body 39 at the light outlet side of the reflector module 39 is embodied, for example, as a fluted

structure, i.e. is for example formed on the molded part, wherein the reflector module 39 is arranged in the illumination arrangement 06 in such a way that the parallel extending flutes are preferably aligned with the movement direction 04 of the material 03. The mirrors 11, 16 and/or the lens 18 can be embodied to be integrated in the reflector module 39. Therefore the reflector module 39 is preferably designed with a depression extending in the longitudinal direction of the illumination arrangement 06. The reflector module 39 is preferably constructed of several segments lined up with each other, wherein each segment constitutes the light beam path fed into the reflector module 39 by one of the light sources 07. The reflector module 39 is preferably mounted on the board 21 supporting the light sources 07, or on the support 27, for example by means of mounting elements 41 formed out of the reflector module 39. At least one reflector module 39 is preferably assigned to each one of the modules M61 to M65 arranged along the width B01 of the illuminated strip 01.

In this way the scattering body 38 of the illumination arrangement 06, the same as the arrangement of the mirrors 11, 16 and/or of the lens 18, simultaneously acts in a shaping and homogenizing manner in regard to the distribution of the light emitted by the light sources 07. The scattering body 38 in particular contributes to a shadow-free, diffused illumination of the illuminated strip 01, even on a surface 02 of the material 03 provided with a delicate structure, wherein in spite of the distance A07 each of the light sources 07 has from the surface 02 of the material 03, the illuminated strip 01 is simultaneously formed as a very bright illuminated band. The arrangement of the mirrors 11, 16 and/or of the lens 18, as well as of the scattering bodies 38 in particular, contributes to the light exiting the illumination arrangement 06 with a homogeneous light distribution, so that therefore an inner structure of the illumination arrangement 06, i.e. the arrangement of its individual light sources 07, is not even represented on a reflecting surface 02 of

the material 03, for example on a reflecting lacquer, a cold seal, a window thread, a patch, or the like, and as a result does not become visible even when viewed under the respective reflection angle.

Fig. 12 represents a plan view of the optical system, wherein the view takes place from a plane extending perpendicularly in respect to the movement direction 04 of the material 03. The illumination arrangement 06 and the illuminated strip 01 illuminated on the surface 02 of the material 03 are arranged parallel in respect to each other at a distance A07, however, the extension of the illumination arrangement 06, i.e. its length B06, can be greater than the length L01 of the illuminated strip 01 or than the width B03 of the material 03. The illumination arrangement 06 is divided into several modules M61 to M65, i.e. in this example into five modules M61 to M65 arranged side-by-side in a line, wherein the light sources 07 arranged in every module M61 to M65 respectively emit light toward the illuminated strip 01. The light reflected by the illuminated strip 01 is then detected by the detector 09 of the detection device 08, which is arranged at a distance A09 from the surface 02 of the material 03, within a spatial detection angle alpha which opens along the length L01 of the illuminated strip 01, wherein in this example the detection angle alpha is of such dimensions that it registers the light reflected at the illuminated strip 01 over the entire length of the illuminated strip 01. The detection angle alpha forms a cross-sectional area on the surface 02 of the material 03, so that the detection angle alpha registers at least a part of the cross-sectional area of the light beam emitted by the illumination arrangement 06 extending over the width B01 of the illuminated strip 01. The cross-sectional area registered by the detection angle alpha preferably is at least as large as the area on the surface 02 of the material 03 defined by the length 01 and the width B01 of the illuminated strip 01. The illumination arrangement 06 and the detection device 08 are preferably arranged spaced apart from each other in the movement

direction 04 of the material 03 in such a way that the light emitted by the light sources 07 of the illumination arrangement 06 onto the surface 02 of the material 03 is reflected by the surface 02 of the material 03 toward the detector 09 of the detection device 08 in accordance with the rule " the angle of incidence is equal to the angle of reflection". But the "angle of reflection" expected as a result of the "angle of incidence", i.e. the reflection angle, can differ from the above mentioned ideal condition, which is based on a completely reflecting area, as a result of the nature of the surface 02 of the material 03, in particular as a function of its structure, in particular micro-structure.

The quality of an image taken by the detection device 08 by means of registering the light reflected at the illuminated strip 01 is decisively dependent on the fact that the light sources 07 of the illumination arrangement 06 emit light at a constant intensity. Fluctuations in the intensity of the light emitted by the light sources 07 have the same result in the detection device 08 in regard to the signal provided to the image processing device 24 as changes in the nature of the surface 02 of the illuminated material 03, so that the causes of a signal change cannot be detected in the image processing device 24. Under these circumstances it is not possible to obtain dependable information regarding the nature of the surface 02 of the illuminated material 03 from am image evaluation performed in the image processing device 24.

Measures which maintain the intensity of the light emitted by the light sources 07 of the illumination arrangement 06 offer relief in this case. The light sources 07 used in the illumination arrangement 06 are preferably embodied as high- intensity light-emitting diodes 07 or laser diodes 07, whose light intensity is a function of temperature. Steps for stabilizing the temperature of the light sources 07 arranged on the support in order to obtain a constant light intensity will be described in what follows. The advantage of the proposed solution lies in that the thermal load on

the light sources 07 is removed directly at the place where it occurs, because of which it is possible to obtain short recovery times.

Preferably the light sources 07 are arranged on a board 21, which can be equipped with additional electronic components and strip conductors. The semi-conductor of the light-emitting diode 07 or laser diode 07 is preferably in direct contact with the board 21, which is designed as an MCPCB (metal core printed circuit board) or as a board 21 with a core of aluminum, and has on its mounting side 32 which supports the light-emitting diodes 07 or laser diodes 07 only a very thin cover on its heat- conducting base for creating the lowest possible heat transmission resistance.

Fig. 13 shows a board 21 with several light sources 07 arranged in lines thereon, wherein the board 21 itself is arranged on a support 27, wherein the support 27 preferably has in its interior, preferably underneath the line-like arrangement of the light sources 07, at least one conduit 28, wherein a liquid or gaseous coolant, for example water or air, flows through this conduit 28. An opening 29 connected with the inflow and an opening 31 connected with the return flow for feeding in and removing the coolant are provided, preferably at the front face of the support, wherein the coolant flows through the support, preferably in a straight line. Fig. 14 shows a support 27 through which the coolant flows in two opposite directions, by means of which a temperature profile is achieved in the support 27 which is balanced along the line-shaped arrangement of the light sources 27. For this purpose the conduit 28 can be reversed by 180° at one end of the support 27.

A regulating device, not represented, can maintain the temperature of the coolant at the inflow and of the flow-through quantity passing through the conduit 28 constant. Alternatively, the regulating device can also keep a difference between the temperature of the coolant at the inflow

and the temperature of the coolant at the outflow constant. In this case the absolute temperature of the coolant is of less importance, instead a maximally permissible temperature for the light sources 07, which results from the heat transfer resistance of the involved materials, should not be exceeded, which is prevented by the regulating device by means of monitoring the temperature and reacting with corrective steps. If no coolant, whose temperature or flow-through quantity can be regulated is available, cooling of the light sources 07 can also take place by means of an external cooling device (not represented), which is not connected with the board 21.

Fig. 15 shows an alternative to the use of a flowing coolant. The board 21 equipped with the light sources 07 is arranged on a support 27, wherein the support 27 itself is arranged on at least one Peltier element 33, preferably on several Peltier elements 33, wherein the Peltier elements 33 are each connected with a cooling body 34 which is thermally separated from the support 27. A required temperature measurement for regulating the at least one Peltier element 33 by means of an electronic regulating device, not represented, is taken directly on the support 27 by a temperature sensor 36. Then, in case of a fluctuating ambient temperature only the temperature of the cooling body 34 fluctuates, but not the temperature of the light sources 07 arranged on the board 21. The electronic regulating device can be integrated into the control device 23 connected with the illuminating arrangement 06.

Since the movement of the moving material 03 in a printing press, or in a machine which further processes a printed product takes place at a speed of several meters per second, for example 3 m/s or more, wherein in a sheet printing press, for example, 15,000 sheets 03 or more per hour are imprinted and transported through the printing press, the optical system must be laid out in such a way that a usable image of the moving material 03 can be taken. Consideration must be given to the fact that, with a detection device 08 designed as a line-scanning camera 08, the

detected amount of the light reflected by the surface 02 of the moving material 03 changes as a function of the speed of the moving material 03. The brightness of the taken picture also changes with this. It is possible that the taken picture becomes useless in case of greater speed changes, such as can customarily occur in the mentioned presses.

Instead of synchronizing the picture-taking of the detection device 08, for example the line-scanning camera 08, with the speed of the moving material 03 by means of an encoder, it is proposed to synchronize a length of switched-on time t3 of a single light source 07 or of a group of light sources 07 of the illumination arrangement 06, which are preferably triggered by an electrical current source 22, in particular a constant electrical current source 22, which is controlled by the control device 23, with the triggering, i.e. the length of exposure time t1 of the line-scanning camera 08, so that the surface 02 of the moving material 03 is always illuminated with the same amount of light, independently of the speed of the moving material 03. From this a constant brightness results for the picture taken by the detection device 08, for example the line-scanning camera 08, over a wide range of the speed of the moving material 03, because the control device 23 always sets the length of switched-on time t3 of a single light source 07 or of a group of light sources 07 of the illumination device 06 lower than the length of exposure time t1 of the line-scanning camera 08.

As already described, several groups of light sources 07 are preferably provided in the illumination arrangement 06, to each of which preferably at least one electrical current source 22, in particular a constant electrical current source 22, is assigned. The lengths of switched-on times t3 of the light sources 07 are controlled by the control device 23 connected with the illumination arrangement 06, for example in groups, or also singly independently of each other by the respective electrical current sources 22, so that a profile of the amount of light can be set over the

length of the light sources 07 of the illumination arrangement 06 , which are preferably arranged in lines. Setting a profile of the amount of light, preferably along the length L01 of the illuminated strip 01, has the advantage that transmission losses can be compensated by means of an optical device, not represented, of the detection device 08, for example the line- scanning camera 08.

It can moreover be provided that a light sensor 37, which is connected with the control device 23, measures the amount of light radiated by the light sources 07 of the illumination arrangement 06 in order to match the length of the switched-on time t3 of the light sources 07 controlled by the control device 23 on the basis of the measuring signal of the light sensor 37 for example to a degradation behavior of the light sources 07, and by means of controlling the light sources 07 to compensate a reduced output of the amount of light radiated because of aging. Also, the control device 23 can match, in particular automatically, the length of the switched-on time t3 of the light sources 07 to different optical properties of the material 03 to be illuminated, for example.

Fig. 16 shows the chronological behavior of the detection device 08, for example the line-scanning camera 08, and that of the light sources 07 of the illumination arrangement 06. The line-scanning camera 08 is switched on at a defined point in time in accordance with the upper, first time progression, so that the length of exposure time t1 of the line-scanning camera 08 starts at this point in time. Following the end of the exposure time t1, an off time t2, which is a function of the speed of the moving material 03, immediately follows between two adjoining image lines of the line-scanning camera 08 which follow each other in the movement direction 04 of the material 03. In accordance with the center, second time progression in Fig. 16, at least one light source 07, which is triggered as a function of the control of the line-scanning camera 08, is turned on by the electrical current source 22 controlled by the control device 23 simultaneously with the length of

exposure time t1 of the line-scanning camera 08 wherein, following a delay time t4 for switching on the light source 07, i.e. after a physically required time until the start of light emission, this light source then remains switched on for a length of switched-on time t3, wherein the length of switched-on time t3, preferably also a sum consisting of a delay time t4 and the length of switched-on time t3, is of shorter length than the length of exposure time t1 of the line-scanning camera 08. The chronological behavior of the line-scanning camera 08 and the light sources 07 is periodically repeated according to the previously described correlation. The chronological behavior of the switched-on time t5 for a constant light source is represented in the lower, third time progression in Fig. 16 only as a comparison with the chronological behavior of the triggered switched-on time t3 of the light source 05.

List of Reference Symbols

01 Pattern, illuminated strip
02 Surface
03 Material, sheet, web of material, imprinted material, securities, banknote
04 Movement direction
05 -
06 Illumination arrangement
07 Light source, light-emitting diode, laser diode
08 Detection device, camera, line-scanning camera, line-scanning color camera
09 Detector, CCD array, photodiode
10 -
11 Mirror, first
12 Effective surface
13 Central beam
14 Central area
15 -
16 Mirror, second
17 Effective surface
18 Lens
19 Partial area
20 -
21 Board
22 Electrical current source, constant electrical current source
23 Control device
24 Image processing device
25 -
26 Partition
27 Support
28 Conduit
29 Opening

30	-
31	Opening
32	Mounting side
33	Peltier element
34	Cooling body
35	-
36	Temperature sensor
37	Light sensor
38	Scattering body
39	Reflector module
40	-
41	Mounting element

A07	Distance
A09	Distance
A18	Distance
B01	Width
B03	Width
B06	Length
L01	Length
Z18	Center

AH1	Envelope surface, first
AH2	Envelope surface, second
AK	Surface, spherical surface
M61	Module
M62	Module
M63	Module
M64	Module
M65	Module

t1	Length of exposure time
t2	Off time
t3	Length of switched-on time

t4 Delay time

t5 Length of switched-on time

alpha Detection angle

omega Solid angle